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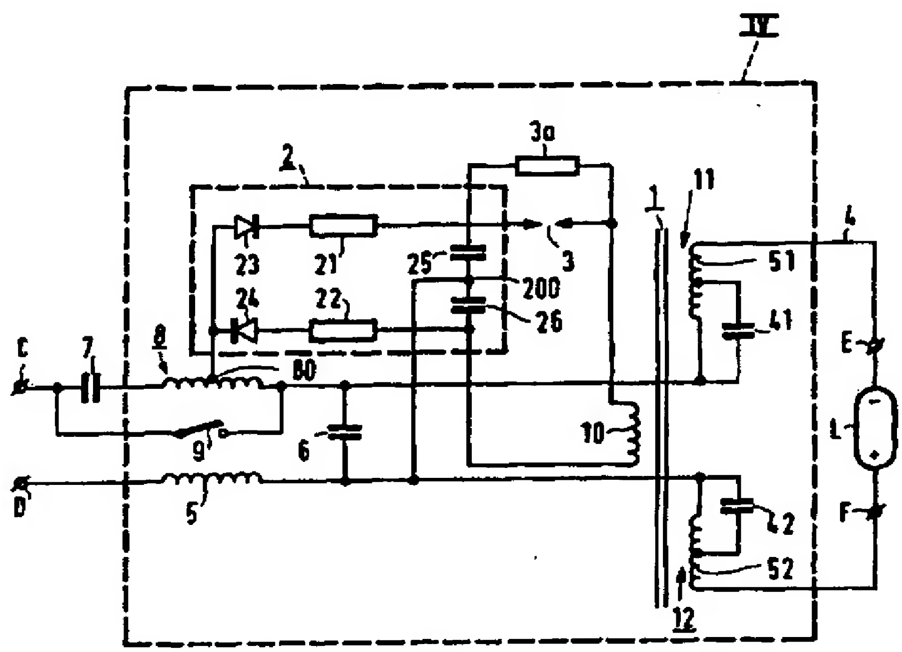

(57) Abstract

The invention relates to a circuit arrangement for igniting a high-pressure discharge lamp (L), provided with: input terminals (C, D) for connection to a supply source; a pulse generating circuit (IV) having a natural frequency and provided with a voltage-dependent breakdown element (3); a pulse transformer (1); and an electrical connection between a secondary winding (11, 12) of the pulse transformer and lamp connection points (E, F). According to the invention, the secondary winding is partly shunted by capacitive means (41, 42). This promotes current take-over after lamp breakdown.

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Circuit arrangement.

The invention relates to a circuit arrangement for igniting a high-pressure discharge lamp, provided with

- input terminals for connection to a supply source;
- a pulse generating circuit having a natural frequency and provided with a voltage-dependent breakdown element;
- a pulse transformer; and
- an electrical connection between a secondary winding of the pulse transformer and lamp connection points.

A circuit arrangement of the kind mentioned in the opening paragraph is known from EP-A-0 398 432 (PHN 12.932 = US-A-5,087,859).

The known circuit arrangement forms part of a circuit for operating and starting a high-pressure discharge lamp in a projection TV system. Special requirements are imposed on a lamp suitable for such an application as to its dimensions and luminous efficacy. The result of this is that an ignition pulse of more than 10 kV, often even more than 20 kV, is required for reliable lamp ignition. A further requirement imposed on the ignition circuit is that an extinguished lamp, which has not or hardly cooled down yet, must be able to re-ignite quickly. Such hot re-ignition requires a re-ignition pulse of an amplitude corresponding to that of the ignition pulse.

In the known circuit arrangement, the voltage pulse in the pulse transformer is applied to the lamp connection points directly from the secondary winding.

Ignition pulse generation takes place in the known circuit arrangement by means of a resonant rise in a tuned LC circuit whereby the voltage across the capacitive means of the voltage-raising network is increased until the breakdown voltage of the breakdown element is reached. For efficient operation, the supply source is commuted with a comparatively high frequency of a few tens of kHz during the ignition pulse generating process. The natural frequency of the pulse generating circuit is the frequency of the tuned circuit formed by the primary winding of the pulse transformer and the capacitive means of

the voltage-raising network. After the connected lamp has ignited and a stable arc discharge has developed, the commutation frequency of the supply voltage switches to a comparatively low value. The lamp behaviour from breakdown up to the moment a stable discharge is achieved is called the ignition phase. The choice of a high commutation frequency in the ignition phase renders possible the use of comparatively small components, while the generation of a sufficiently high voltage will take up comparatively little time. This does presuppose, however, that the supply source circuit must be equipped with means for changing the commutation frequency in dependence on the state of the lamp.

A problem of the known circuit arrangement lies in the take-over by the supply source of the supply of current to the lamp immediately after lamp breakdown. This so-called take-over behaviour shows an undesirable gradient in many cases in the known circuit arrangement, *i.e.* the supply of current is initiated too slowly, so that the ionization in the lamp is lost and a new ignition pulse is necessary.

The invention has for its object to provide a solution to the problem mentioned above.

This object is achieved in that a circuit arrangement of the kind mentioned in the opening paragraph, according to the invention, is characterized in that a portion of the secondary winding of the pulse transformer is shunted by capacitive means.

The inventors have found that a very short, high current peak can occur immediately after breakdown. It is surprisingly found that the use of the measure according to the invention strongly damps said current peak, so that current flows through the lamp over a longer period, and ionization in the discharge vessel accordingly occurs. This strongly promotes a good take-over behaviour.

The circuit arrangement according to the invention also has the advantage that the circuit formed by the secondary winding of the pulse transformer, the capacitive means, and the lamp connection terminals forms a tuned circuit with which a pulse generated in the pulse generating circuit is converted into an ignition pulse across the connected lamp with only slight losses, whereas signals of other frequencies are strongly damped in the tuned circuit. The tuning may be chosen to lie at the natural frequency of the pulse generating circuit. Such a tuning is favourable not only for an efficient coupling-in of the ignition pulse,

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but also because it is counteracted that semiconductor switches become defective owing to high-frequency signals. In an advantageous embodiment, the tuning is chosen to lie at or near an even harmonic frequency, in particular the second harmonic of the natural frequency. It is surprisingly found that a further increase in the generated pulse can be achieved thereby without larger components being necessary. On the other hand, the use of a harmonic frequency renders a further reduction of the pulse generating circuit, in particular a smaller pulse transformer.

With the lamp in a stable operational state, the secondary winding forms a negligible impedance and accordingly does not give rise to an appreciable dissipation. This is in contrast to resistive means which are suitable in principle for use as elements of the filter.

Preferably, the secondary winding is built up from a first and a second secondary winding of equal dimensions and applied symmetrically relative to the lamp connection points, each secondary winding being partly shunted by capacitive means. This is particularly favourable as a measure for counteracting the occurrence of interference fields resulting from the pulse generation. The use of a coaxial conductor to a lamp connection point is not necessary for this purpose.

The above and further aspects of the invention will be explained in more detail with reference to a drawing of an embodiment, in which

Fig. 1 is a diagram of a circuit for igniting and operating a lamp of a TV system,

Fig. 2 shows a portion of Fig. 1 which serves for igniting the lamp, and

Fig. 3 shows the voltages generated by the circuit arrangement of Figs. 1 and 2.

In Fig. 1, A,B are connection terminals for connecting a supply voltage source, for example a supply source of 200 to 400 V DC. Filtering takes place in I by means of an input filter. In an alternative embodiment, A and B form connection terminals for connection to a public mains of 220 V, 50 Hz. Rectification of the supply voltage then takes place in I. I will also comprise provisions in that case for preventing mains voltage distortion owing to the operation of the circuit arrangement.

Component II forms a switch mode power supply with which a commutator circuit III is fed. The commutator circuit acts as a commutating supply source

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with a square-wave supply voltage. The commutator circuit III is connected to a lamp circuit V *via* input terminals C,D, the lamp circuit comprising a pulse generating circuit IV and lamp connection points E,F between which a lamp L is connected. The lamp circuit V forming part of the circuit of Fig. 1 is depicted in Fig. 2.

In Fig. 2, input terminal C is connected to a pulse transformer 1. A primary winding 10 of the transformer 1 is connected in series with a voltage-dependent breakdown element 3 between input terminals C and D *via* a voltage-raising network 2. A first secondary winding 11 of transformer 1 is connected on the one hand to input terminal C *via* a series circuit of a decoupling capacitor 7 and a self-inductance 8. On the other hand, the first secondary winding 11 is connected through a conductor 4 to lamp connection point E, thus forming an electrical connection between the secondary winding of the pulse transformer and lamp connection points. The first secondary winding is partly shunted by a capacitor 41, which forms capacitive means. A second secondary winding 12 of transformer 1 is connected in a similar manner on the one hand to input terminal D *via* a self-inductance 5 and on the other hand to lamp connection point F. The second secondary winding is partly shunted by a capacitor 42 forming capacitive means. Self-inductance 5 serves as a protection against too high inrush currents through the commutator switches.

The voltage-raising network 2 of capacitive, inductive, and rectifying means comprises a first branch with an ohmic impedance 21 and a diode 23 connected on the one hand to a tap 80 of self-inductance 8 and on the other hand to the voltage-dependent breakdown element 3. The network also comprises a second branch with an ohmic impedance 22 and a diode 24 connected on the one hand to tap 80 of self-inductance 8 and on the other hand to the primary winding 10 of pulse transformer 1. The two ohmic impedances 21, 22 are interconnected by a series arrangement of two capacitors 25, 26 of which a common junction point 200 is connected to input terminal D *via* self-inductance 5. Transformer 1, voltage-raising network 2, and voltage-dependent breakdown element 3, shunted by a leakage resistance 3a, together form a pulse generating circuit IV. Portions 51, 52 of the secondary windings 11, 12 together with the capacitive means 41, 42 form a filter during the ignition phase, of which filter the lamp connection points E and F also form part. The tuning of the filter is so chosen in relation to the natural frequency of the pulse generating circuit that the combination forms a band-pass filter for the second harmonic of the natural frequency of the pulse generating circuit, *i.e.* the circuit formed by capacitors 25, 26 and the primary winding 10 of the pulse transformer 1.

In addition, the self-inductances 5 and 8 are interconnected by a capacitor

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6, the self-inductance 8 and capacitor 6 forming a tuned LC circuit during pulse generation. During pulse generation, the voltage across the capacitive means 25, 26 of the voltage-raising network 2 is increased until the breakdown voltage of the breakdown element 3 is reached by means of a resonant rise in the tuned LC circuit 6, 8.

The decoupling capacitor 7 and the self-inductance 8 are shunted by a controlled switch 9. The switch is open during pulse generation. The moment the commutation frequency switches to a comparatively low value belonging to stable lamp operation, the switch 9 is also closed.

In a practical realisation of an embodiment as described above, the circuit arrangement is suitable for igniting and operating a 100 W Philips high-pressure mercury lamp of the UHP-100 type. The rated lamp voltage is 85 V and the rated lamp current frequency is 180 Hz.

In the practical realisation of the embodiment described here, the circuit arrangement is designed for connection to a supply voltage of 200 to 400 V DC at connection terminals A,B. Components I and II are an input filter and a downconverter, respectively. The downconverter is provided with a power control such that a voltage of 160 V obtains at the output of the downconverter in the ignition phase and a voltage of 85 V in the stable operational state of the lamp.

The commutator circuit III is constructed as a full bridge circuit. The commutator supplies a square-wave supply voltage of approximately 160 V in the ignition phase and a square-wave voltage of 85 V in the stable operational state of the lamp.

Lamp ignition proceeds as follows. Since the commutator circuit commutates at a frequency of 60 kHz, a resonant rise of the voltage takes place in the LC circuit 6, 8. This leads to a peak voltage of 800 V at the lamp connection points. The two diodes 23, 24 of the voltage-raising network together with the capacitors 25, 26 ensure that the peak voltage of approximately 550 V at the area of tap 80 is increased to a maximum of 1100 V across the capacitors 25, 26. The voltage-dependent breakdown element is a spark gap, make Siemens, with a breakdown voltage of 800 V which is shunted by a leakage resistance 3a of 10 MΩ to achieve a satisfactory operation of the voltage-rising network. This in fact achieves that the voltage across the capacitor of the network is well-defined. This shunt resistance is also desirable for reasons of handling safety. Also for safety reasons, a PTC resistor (not shown) may be included in the connection between the capacitors of the voltage-raising network and the self-inductance 5. The capacitors 25, 26 each have a value of 120 nF, the ohmic impedances 21, 22 of 33 kΩ.

The pulse transformer is a high-voltage transformer with a ferrite rod core, a primary winding of 3 turns, and a first and a second secondary winding each comprising 7 sections of 11 turns each. Both the primary winding and the secondary windings are formed from wire of 500 μm diameter. The coupling between primary and secondary windings here is 0.7. The coupling between the two secondary windings mutually is 0.9. The transformer has a leakage self-inductance of 364 μH measured at the secondary windings with short-circuited primary winding. Each of the secondary windings is shunted across 3 sections by a capacitor of 220 pF.

The pulse thus generated has a value of approximately 20 kV. The generated ignition pulse is pictured in Fig. 3. Fig. 3A shows the voltage pulse at the primary winding of pulse transformer 1, and Fig. 3B the voltage pulse at the secondary winding of the pulse transformer 1. Time t is plotted on the horizontal axis in units of 500 ns per graduation. The voltage V is plotted on the vertical axis in kV.

It is evident from Fig. 3B that the generated pulse has a width b of 200 ns at a pulse level of 10 kV. The pulse in Fig. 3A has a frequency of 1 MHz. The pulse in Fig. 3B has a frequency of 2 MHz.

The generated pulse leads to breakdown in a lamp which has not yet ignited. After the breakdown of the lamp, the latter starts its run-up and reaches the stable operational state after some time. This is found to occur after approximately 700 ms in the lamp described, after which the lamp voltage rises further to the rated value. After a period of 1 s after breakdown across the lamp, the commutation frequency of the commutator circuit is reduced to 180 Hz, and the lamp has reached its nominal operational state.

In the case of a lamp which has extinguished, but not yet cooled down, the generated pulse causes hot re-ignition within 30 s.

Although in the embodiment described the voltage-raising network is connected to a tap of the self-inductance 80, it is equally well possible to situate this connection between the self-inductance 8 and capacitor 6.

The choice of the values of the shunt capacitors 41, 42 appears to be not very critical. It was empirically found that they should preferably lie between 150 pF and 400 pF for each capacitor in the circuit described. A higher value within said range will generally lead to a quicker hot re-ignition. Capacitance values outside said range result in a reduced pulse height.

More in general, the values of the capacitive means are so chosen that the following relation is satisfied:

$$2.2 < n^2C_s/c_p < 8.8$$

where:

n is the winding ratio of the pulse transformer,

C_s is the value of the capacitive means shunting the second winding of the pulse transformer, and

C_p the total capacitance value of the pulse generating circuit.

CLAIMS:

1. A circuit arrangement for igniting a high-pressure discharge lamp, provided with

- input terminals for connection to a supply source;
- a pulse generating circuit having a natural frequency and provided with a voltage-dependent breakdown element;
- a pulse transformer; and
- an electrical connection between a secondary winding of the pulse transformer and lamp connection points,

characterized in that a portion of the secondary winding of the pulse transformer is shunted by capacitive means.

2. A circuit arrangement as claimed in Claim 1, characterized in that the secondary winding of the pulse transformer and the lamp connection points form part of a tuned circuit whose tuning is chosen to lie at or near the natural frequency of the pulse generating circuit.

3. A circuit arrangement as claimed in Claim 1, characterized in that the secondary winding of the pulse transformer and the lamp connection points form part of a tuned circuit whose tuning is chosen to lie at or near an even harmonic of the natural frequency of the pulse generating circuit.

4. A circuit arrangement as claimed in Claim 1, 2 or 3, characterized in that the secondary winding is built up from a first and a second secondary winding.

5. A circuit arrangement as claimed in Claim 4, characterized in that the first and second secondary windings have equal dimensions and are provided symmetrical to the lamp connection points, each secondary winding being partly shunted by capacitive means.

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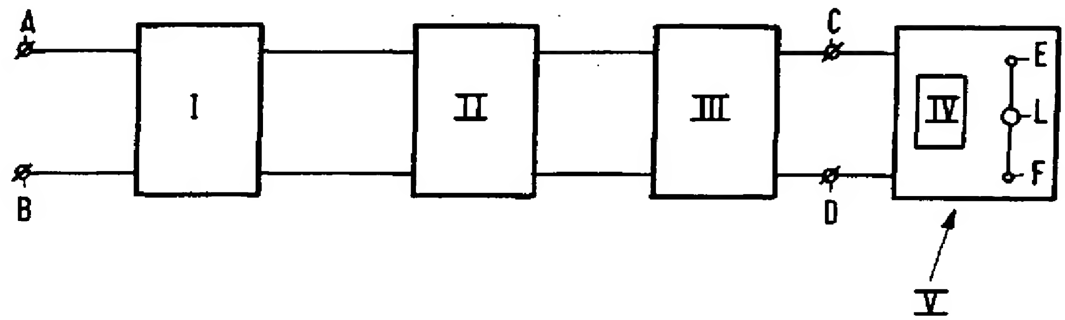
A
B
I
II
III
C
D
IV
E
L
F
V

FIG.1

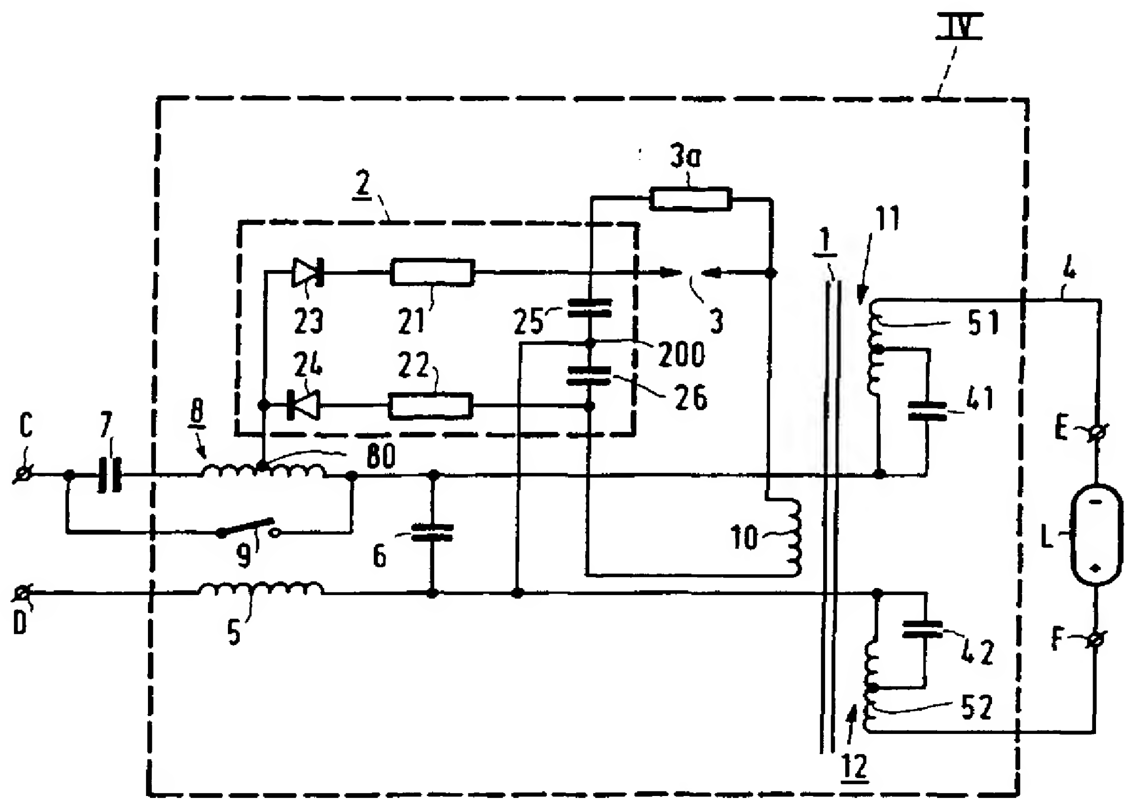
IV
3a
2
11
1
4
23
21
25
3
51
200
24
22
26
41
C
7
8
80
E
9
6
10
L
D
5
42
F
52
12

FIG.2

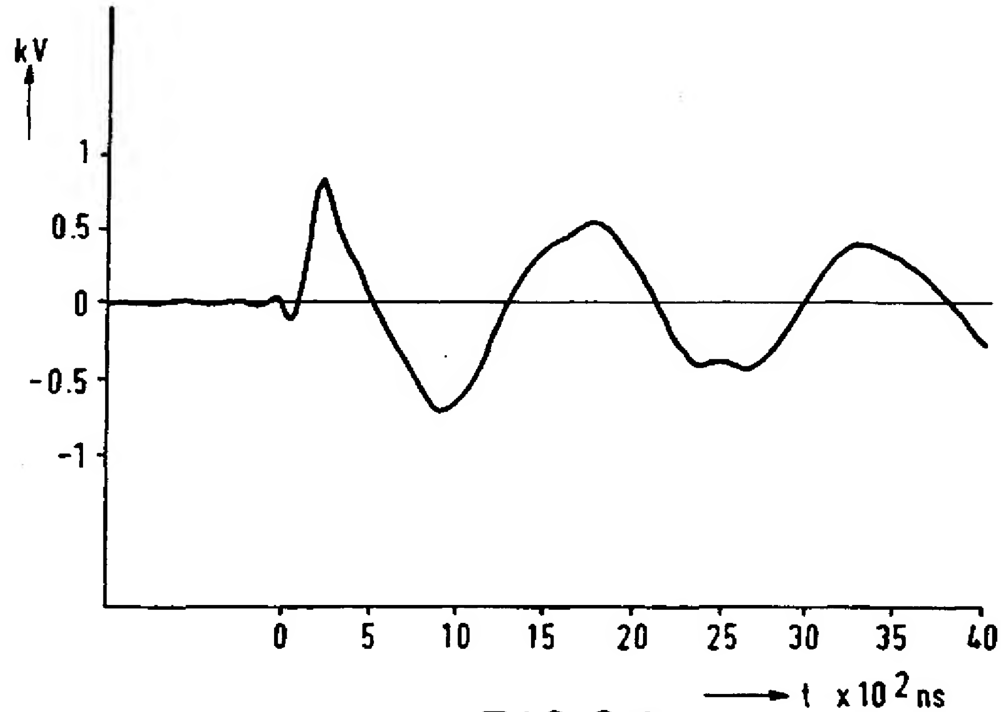
kV
1
0.5
0
-0.5
-1
0
5
10
15
20
25
30
35
40
t x10 2 ns

FIG.3A

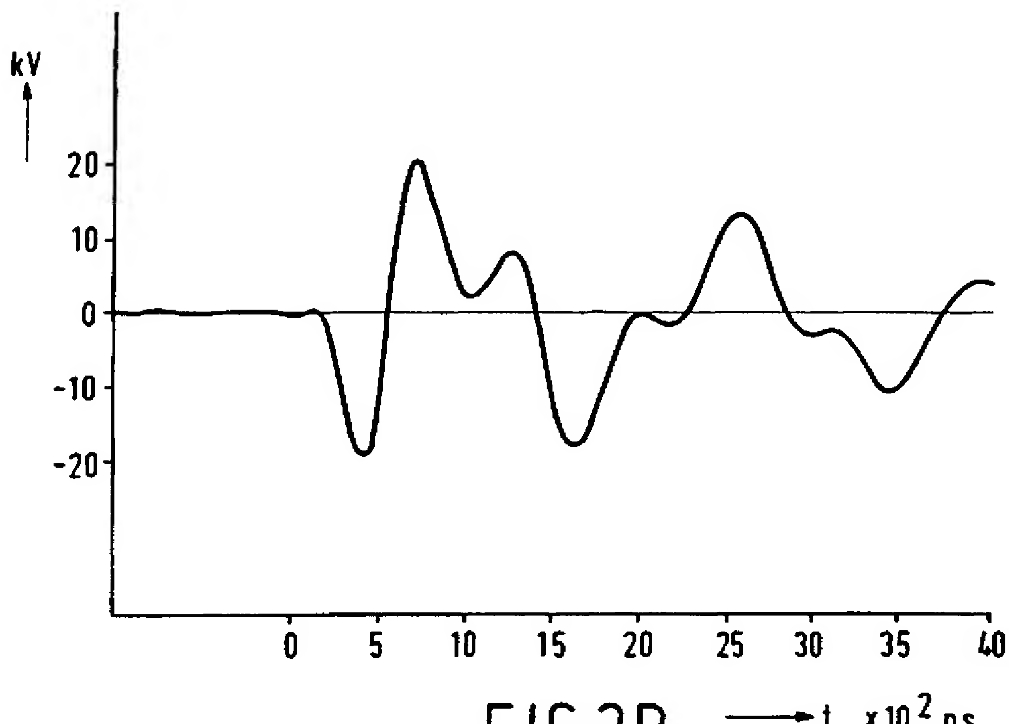
kV
20
10
0
-10
-20
0
5
10
15
20
25
30
35
40
t x10 2 ns

FIG.3B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 96/00115

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H05B 41/04, H05B 41/29
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5084655 A (E. VAN ZANTEN), 28 January 1992 (28.01.92), figure 1, abstract --	1-5
A	US 5087859 A (H.J. BLANKERS), 11 February 1992 (11.02.92), column 3, line 42 - column 4, line 21, figure 2 --	1-5
A	US 4749914 A (Z. FEHER ET AL), 7 June 1988 (07.06.88), figure 3, abstract --	1-5
A	US 5387845 A (O.K. NILSSEN), 7 February 1995 (07.02.95), figure 2, abstract -- --------	1-5

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
27 June 1996	28 -06- 1996
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Bertil Nordenberg Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

Information on patent family members

01/04/96

International application No.

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US-A- 5387845	07/02/95	NONE	

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